Nuclear & Powder Met (file)

CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

MINES BRANCH

OTTAWA

PHYSICAL METALLURGY DIVISION

TEST REPORT PM-69-9

EXAMINATION OF COLD-ROLLED NICKEL PLATE END CONTAINING DEFECTIVE ZONE (AMSTED SLAB, INCO CONTROLLED-ROLLING EXPERIMENT)

by

C.F. Dixon and N.S. Spence

Nuclear and Powder Metallurgy Section

May 21, 1969

Restricted Distribution

90-04657/

PHYSICAL METALLURGY DIVISION

TEST REPORT PM-69-9

To: Mr. E.F. Brown,
Acting Master,
Royal Canadian Mint,
Ottawa, Ontario.

Re: Examination of Cold-rolled Nickel Plate End Containing Defective Zone.(Amsted Slab, Inco Controlled-rolling Experiment).

INTRODUCTION AND SUMMARY

A slab of pure nickel cast by the Amsted controlled-pressure technique was experimentally rolled under arrangements made by International Nickel Company (Inco), with another U.S. mill having specialized equipment. The cast slab, originally 2 in. thick, was reduced to 0.25 in. prior to shipment to Inco at Huntington, West Virginia, for finish cold rolling to coin thickness strip. After the initial breakdown to 0.25-in. plate, in-plant inspection indicated an internal defect near one end which was confirmed by inspection at Huntington. Prior to finish rolling at Huntington, the end of the plate, approximately 10 in. long, containing the defect was cut off. The finished coin-thickness strip and the defect-containing scrap were delivered to the Royal Canadian Mint.

It was suggested that metallographic examination of the scrap piece might be useful to confirm the presence of the indicated defect and possibly to provide a clue as to its origin. The piece was delivered to the Physical Metallurgy Division and subjected to ultrasonic inspection by the Non-destructive Testing Section. The presence of a lenticular zone of indicated discontinuity was confirmed, extending from near the end to a distance some 6 in. along the length. The maximum width of the indicated zone was about 1-1/2 in.

It was decided to cut the plate in such a manner that samples containing the indicated defect and sound metal could be obtained for metallographic examination. The presence of a zone of discontinuity was confirmed, and evidence of superficial oxidation on its surface suggests that the original void was opened to the atmosphere at some time after casting. It seems probable that the defect originated in a shrinkage cavity produced

during solidification due to incomplete feeding, and that the original defect, as formed, was closed to the atmosphere but may have been provided with access to air following subsequent cutting of the ingot into individual rolling slabs.

PROCEDURE AND RESULTS

The cold-rolled nickel plate was first subjected to ultrasonic testing. A defect, of the shape shown by the cross hatched area in the photograph in Figure 1, was detected. The piece was then cut into specimens as shown in Figure 1. Macroexamination and microexamination of cross-sections AF, (F'F')F' and BF (see Figure 1) showed the presence of a discontinuity or crack, in the crosshatched area, located halfway through the thickness of the nickel plate in a plane parallel to the top and bottom. This defect was continuous in most of the area examined and is illustrated in the photomicrograph of cross-section BF in Figure 2. In some places, the defect appeared as shown in the photomicrograph in Figure 3 (cross-section BF). These micrographs (Figures 2 and 3) show that the defect influenced the shape and size of the grains, which indicates that the original defect was present when the grains were formed.

For further examination of the defect, a 1/2-in. square was cut from the crosshatched area. Because of the discontinuity, it was possible to pull the top half of the specimen from the bottom half. The inner surfaces of the discontinuity were examined by an electron-scan microscope. Figure 4 (electron-scan micrograph) shows the smooth surface in the discontinuity as well as the edge of the sample where there was no "crack" and where the metal was torn apart during separation of the sample.

There was some slight discolouration on the inner surfaces and analysis by an electron microprobe showed the presence of an oxide film. The amount present was very little but evidently sufficient to prevent welding during rolling.

METALLOGRAPHY

Specimens for macroexamination were rough polished on silicon carbide abrasive paper to a 600 grit, then with 9-micron diamond paste on a "Metron B" cloth. This was followed by etching for 1 minute with a

solution containing 50 parts nitric acid and 50 parts glacial acetic acid.

For microexamination, specimens were rough polished as above, then further polished with 3-micron diamond paste and magnesium oxide on a "Metron A" cloth. These specimens were etched for 10 seconds with the above solution.

CONCLUSIONS

1. There was a defect in the cold-rolled nickel plate in the form of a discontinuity located halfway through the thickness of the plate in a plane parallel to the top and bottom. The defective area was tear-drop in shape.

2. The defect was present prior to recrystallization.

3. The smooth inner surfaces of the discontinuity indicate that it was present during working.

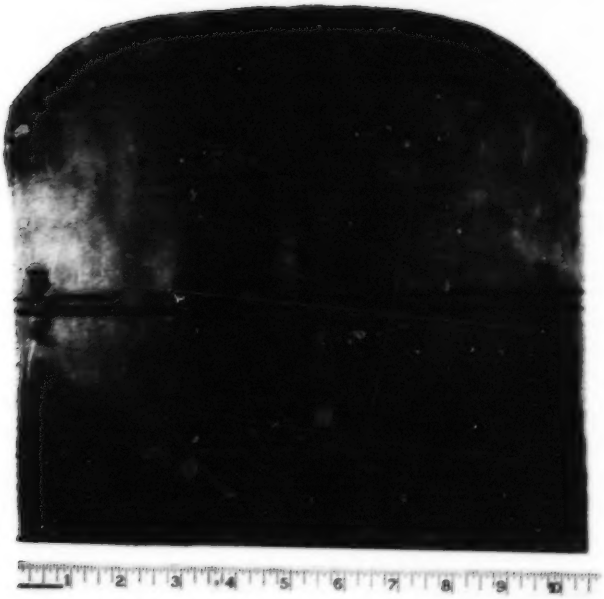
4. The presence of oxide on the surfaces of the discontinuity indicates that some exposure to the atmosphere had occurred.

C. F. Dixon

CFD:NSS:lc

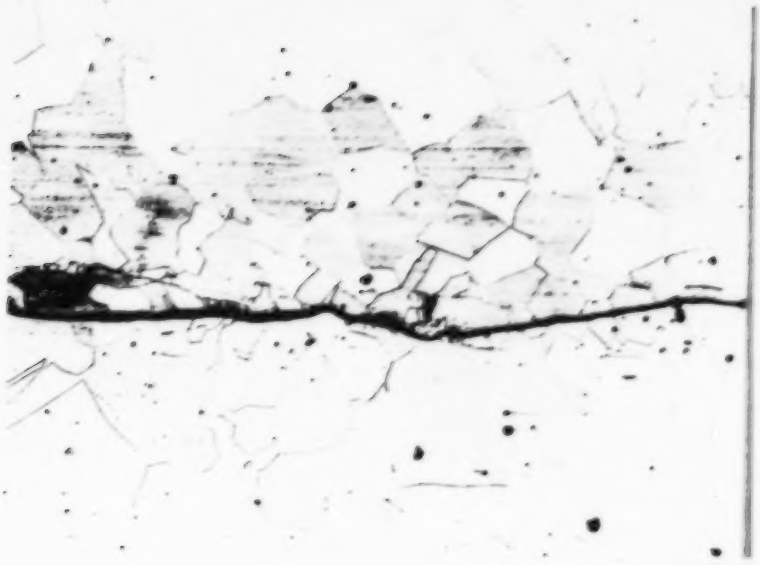
N.S. Spence

Nuclear and Powder Metallurgy Section.



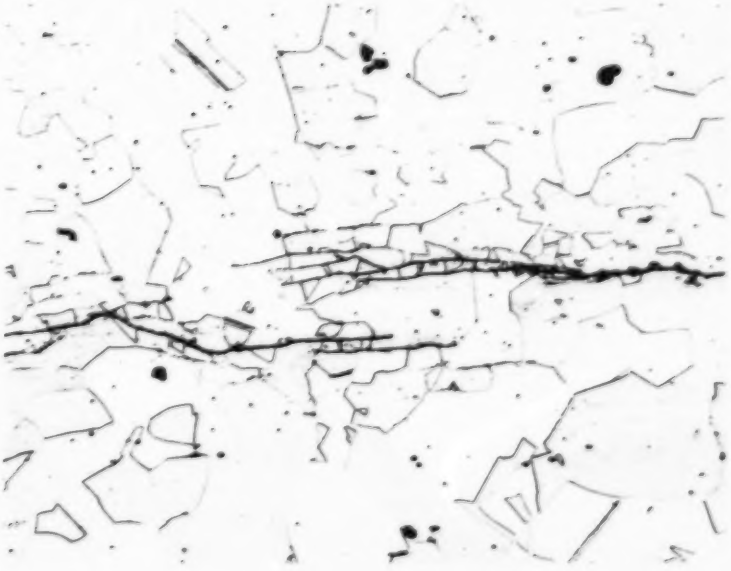
X 1/3

Figure 1. Nickel Cold-rolled Strip.



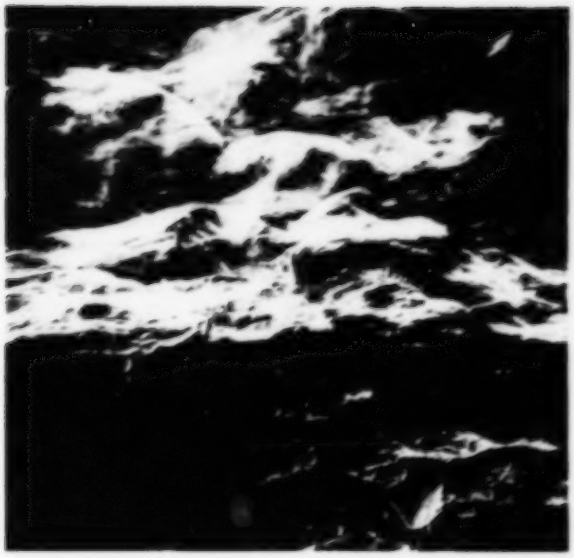
X 100

Figure 2. Nickel Cold-rolled Strip. Etched.



X 100

Figure 3. Nickel Cold-rolled Strip. Etched.



X 180

Figure 4. Nickel Cold-rolled Strip.
Electron-scan Micrograph.
Inside Crack.